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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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Introducing economic relationships into the MEPS-model (Methodology for processing and programming food production and consumption systems) with emphasis on income, prices and consumption.

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Bernhard Böhm
(consultant)
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Contents:

Part A:

The theoretical structure of the revised demand module of MEPS

1. Introduction

The revision of this module of MEPS concentrates on the determination of individual (ie. per capita) demand for final consumption goods. As policy oriented aspects, like planning the satisfaction of certain needs, will have to depend on the demand for commodities, the emphasis of demand analysis is placed on relations expressed in terms of goods (in physical units and prices of goods). Per capita demand for goods is determined by expenditure (income) and price variables. Expenditures and incomes are related to national aggregates which are taken as given for this module. Prices may be taken as being determined in conjunction with production modules, only in the production modules, or as being determined exogenously. The role for planning satisfaction of certain needs is changed as a consequence. Since quantities are determined in dependence of prices and incomes satisfaction levels can be calculated on that basis and the degree of realization of announced goals can be checked. Under certain circumstances regarding supply - demand interaction situations of demand rationing may occur. By manipulation of given restraints on supply and imports it is possible to change the degree of rationing and in turn that of the satisfaction achieved. The scope for satisfaction derived from one commodity is generalized to allowing the satisfaction of more than one need simultaneously. This permits consideration of multiple objectives and provides a link for policy analysis.

The basic theoretical considerations concerning the demand module itself as well as its relation to production modules are presented in the following sections.

2. Determination of per capita consumer demand for final goods

2.1.
Denote by c(i,g,t) the per capita consumer demand for the physical amount of good i, of consumer group g, in period t. In order to permit competition among domestically and imported consumer goods assume there are n consumer goods available of which m are imported from abroad:
i = 1,...,m-1,m,m+1,...,n with i = 1,...,m imported goods, and
i = m+1,...,n domestically produced goods.
There may be cases where a commodity is available from domestic production and also imported. This may have two reasons:

a) There is no sufficient quantity from domestic production so that in order to fulfill demand some imports are necessary (possibly under some constraints),

b) there is sufficient quantity available from local production but the good is nevertheless imported because of some trading arrangements or price considerations (e.g. in case of the competitive situation without trade restrictions a foreign supplier may decide to enter the market).

The definition of goods above is sufficiently general. There may be some identical commodities in the set $G' = \{c_i;\ i=1,\ldots,m\}$ and in $G'' = \{c_i;\ i=m+1,\ldots,n\}$ too. What matters is the consumers demand for commodities which are supposed to be differentiated w.r.t. origin or price. A commodity is considered identical for the consumer if it carries the same price and is physically similar. The consumer is supposed to be indifferent between local and imported goods if the price is the same. If this assumption actually does not hold true (i.e. there is a difference in preferences for the same good depending on whether it is an imported one or locally produced) then they will be regarded as two different commodities which happen to have the same price. The decision about the appropriate treatment of commodities in this respect must be taken by the user of MEPS. See also section 3.

2.2.

For simplicity we shall assume that the price of one commodity will be the same for each group of consumers g=1,...,H. If necessary this assumption can be relaxed. This implies price discrimination which has to be handled in the price determination section either of the production module or the total system. If price discrimination prevails the respective commodity's group price must be considered.

Denote the price of good i in period t by p(i,t), or in the case of price discrimination distinguished also according to consumer group g as p(i,g,t).

In most applied cases this demand module will not relate to the entire set of consumer goods in one country. Therefore, we have to assume seperability of preferences for the subgroups of commodities considered with respect to all other commodities in the country. In addidtion, to permit adequate flexibility in the design of this module we have to assume seperability of preferences also for the goods considered within the given application. Thus, the following system of consumer demand equations is proposed:

$$c(i,g,t) = a(i,g) + (1/p(i,g,t))*b(i,g)*[y(g,t) - \sum_{j \in G} (p(j,g,t)*a(j,g))] \qquad (1)$$

with $G = G' \cup G''$ for the whole set of consumer goods i=1,...,n covered in the application; each consumer group g=1,...,H; and period t=0,...,T where T denotes the planning horizon and t=0 is the base period. y(g,t) denotes total expenditure on all consumer goods covered in the application. a(i,g) and b(i,g) are constants. Some further explanation follows.

This demand system corresponds to the "Linear Expenditure System" developed by R. Stone (cf. R. Stone (1954) "Linear Expenditure Systems and Demand Analysis: An Application to Patterns of British Demand", Economic Journal 64, 511-527). In our context the system is not applied to the whole set of consumer demand functions but to subgroups of consumer goods. Therefore, variable y(g,t) corresponds to the total amount spent on the goods in question, conditional on expenditures on those goods not covered in this application.

The interpretation of the constant parameters a and b which have to be supplied by the user seems to be rather appropriate for the present purpose of consumer demand planning:

a(i,g) can be interpreted as the minimal quantities demanded and should be related to what one may call subsistence levels of the demanded good. In fact, one may derive these figures from some available statistics reporting minimal needs and respective quantities of those goods required for survival.

Σ_i(a(i,g)*p(i,g,t)) is therefore the minimal total expenditures for the goods in question required for maintaining subsistence. One should have
$0 \leq a(i,g) \leq c(i,g,t)$ (all t)
to preserve a meaningful interpretation.

b(i,g) denotes the fixed proportions which are used to allocate the expenditure sums exceeding the necessary minimum among the goods covered in the model. b(i,g) is assumed to be positive and should sum to one over the goods in question for each group, i.e.
Σ_i b(i,g) = 1 for all g, i up to n.
They can also be interpreted as marginal budget shares i.e.
d[p(i,g,t)*c(i,g,t)]/dy(g,t).
The b(i,g)'s equal the actual budget shares if the a(i,g)'s are all zero. In the absence of proper estimates from time series or cross section observations or from consumer surveys one may try to use values which are close but not equal to average budget shares.

2.3.
It is important to supply adequate figures for y(g,t). In essence this variable is a fraction of total consumption expenditures corresponding to the commodities or groups under investigation. Note that the sum of the product of all these prices times physical quantities must add up to the expenditures y(g,t). The idea of the present implementation of such a system is to determine the available sum (per capita) in dependence of other known or given variables. Thus, an estimate for y(g,t) may be derived from simple consumption functions relating this quantity to the respective total per capita incomes. This variable will, therefore, provide the link between macroeconomic variables and the microeconomic ones. Details will be discussed below.

2.4.
Some further remarks on the properties of this demand system seem to be in order. The LES is somewhat restrictive as it assumes an additively separable preference structure. Apart from the fact that this assumption is the price paid for keeping the system flexible for different applications which may well be independent from each other, the implied comparative static properties do make sense in the present problem context. There are no specific substitution effects - referring to the intrinsic substitution relations between commodities. General substitution effect, of

course, exist and, therefore, imply that all goods considered must be regarded as (general) substitutes to each other in the sense that each commodity competes for the consumers money. These effects may be calculated as:

$$\frac{b(i,g)*b(j,g)}{p(i,g,t)*p(j,g,t)}*[y(g,t) - \sum_{k \in G} (p(k,g,t)*a(k,g))] > 0.$$

The income (expenditure) elasticities are

$$e(i,g,t) = dc(i,g,t)*y(g,t)/dy(g,t)*c(i,g,t) = = b(i,g)*y(g,t)/p(i,g,t)*c(i,g,t). \quad (2)$$

Prior knowledge of such elasticities will be of great help to determine parameters b(i,g) resulting from multiplication of e(i,g,t) by the relevant budget share $w(i,g,t) = p(i,g,t)*c(i,g,t)/y(g,t)$.

Direct price elasticities are given by

$$dc(i,g,t)*p(i,g,t)/dp(i,g,t)*c(i,g,t) = = [a(i,g)*(1 - b(i,g))/c(i,g,t)] - 1. \quad (3)$$

Indirect price elasticities are

$$dc(i,g,t)*p(j,g,t)/dp(j,g,t)*c(i,g,t) = = -[a(j,g)*b(i,g)*p(j,g,t)]/p(i,g,t)*c(i,g,t) \quad (4)$$

Information on such magnitudes from consumer studies will be helpful in the calibration of the model i.e. the determination of the parameters a, given information on b.

2.5.
Summing up, the demand for physical consumer goods is determined by their prices and the sum available for their purchases (being itself dependent on incomes and other variables from the macro economy). The parameters in the equations refer to subsistence quantities and marginal budget shares which can be estimated from available statistics.

3. Aggregate demand and income

3.1.
The per capita variables c(i,g,t) and y(g,t) are converted to (group) aggregates by multiplication with the appropriate population variable:

$$C(i,g,t) = c(i,g,t)*pop(g,t) \quad (5)$$
$$Y(g,t) = y(g,t)*pop(g,t) \quad \text{all } i,g, \text{ and } t. \quad (6)$$

Summing over the population groups will yield total consumer demand for physical good i in period t:

$$CT(i,t) = \sum_g C(i,g,t) \quad \text{all } i \text{ and } t. \quad (7)$$

This is the quantity relevant for linking the demand module with the production module.

An important question which must be discussed now is about the kind of information available for the determination of the per capita expenditures on the goods under analysis. It will be different if one starts consumption planning at the macro level or at the individual (per capita) level.

1) Assume for the first case that plans are drawn up from the national level. The variables available from national accounts are:

total disposable income at current prices, YDT,
total consumer expenditures at current prices, CNT,
a consumer price index (or deflator), PCT,
the breakdown of all these variables (with a possible exclusion of prices) into quantities relating to groups of the population g=1,...,H, denoted by indexing the total variables with (g).

Also, the breakdown of total (group) consumers expenditures into commodity categories must be known (e.g. from consumer surveys). Denote the share of consumer expenditure of population group g on all goods entering the analysis by v(g,t) to allow changes over time. Then

$$Y(g,t) = v(g,t)*CNT(g,t), \quad g=1,...,H. \tag{8}$$

$$CNT(g,t) = r(g,t)*CNT(t), \quad g=1,...,H, \tag{9}$$

will establish the relation between total expenditures and those of groups with r(g,t) > 0 denoting the ratio of population group consumption to total where

$$\sum_g r(g,t) = 1. \tag{10}$$

Assume a macroeconomic consumption function has the general form

$$CRT(t) = CNT(t)/PCT(t)*100 =$$
$$= f((YDT(t)/PCT(t)*100), Z(t)), \tag{11}$$

where Z(t) relates to a vector of macro-variables which may reflect demographic or social characteristics and could contain also lagged variables (e.g. incomes) and, of course, policy variables. Given nominal disposable income and the consumer price index total consumer demand at constant prices (CRT(t) will usually be the relevant dependent variable. Defining

$$CNT(t) = CRT(t)*PCT(t)/100 \tag{12}$$

we can determine the nominal amount of expenditures of population group g on all goods covered in the analysis by

$$Y(g,t) = v(g,t)*r(g,t)* CNT(t), \quad g=1,...,H. \tag{13}$$

The shares v and r must be given. Dividing by the respective population group produces the per capita expenditures y(g,t) which enter the demand functions.

2)
If sufficient information on the population group level is available the consumption function may be set up to explain group consumption as dependent on group income and other macro-variables relevant for groups. This might be the case if planning starts with per capita information on the microeconomic level. The procedure to establish the link with macroeconomic variables proceeds with the following arguments:

Assume that per capita expenditures of group g on the commodities under investigation are related to their total per capita income according to e.g.

$$y(g,t) = f_g(yn(g,t),\ A(g,t)), \quad \text{all } g, \tag{14}$$

where yn(g,t) denotes per capita nominal incomes of group g in period t, and A(g,t) denotes a vector of group attributes relevant in determining the (per capita) income allocation to y(g,t). Inclusion of A(g,t) will permit macroeconomic policy measures to be transmitted to the actual sectoral or firm level. Careful specification of the variables to be included in A(g,t) at the implementation level of MEPS will be of great relevance in establishing a sound link between the macroeconomic sphere and the micro-(application) sphere. Examples of variables to consider may include taxes, age structure, proportion of land owners, educational variables, and dummy variables for various reasons.

Summing the product yn(g,t)*pop(g,t) over all groups g=1,...,H yields total nominal (disposable) income (YDT(t)) which is a key macro-variable:

$$\sum_g (yn(g,t)*pop(g,t)) = YDT(t) \tag{15}$$

3.2.
As CT(i,t) is total demand for good i in period t it is composed of quantities supplied domestically and imported:

$$CT(i,t) = CTd(i,t) + CTm(i,t). \tag{16}$$

CTd(i,t) denotes that part of physical demand for good i which should be satisfied domestically, CTm(i,t) that one which is satisfied by imports. Now, it may be argued that from the point of the consumer one cannot determine the size of each component unless commodity i belongs exclusively to one of the two sets G' or G''. For this reason we have permitted in section 2.1 that some goods might enter both sets even if they are considered identical. In such a case each of the two identical commodities will relate to a different index i=1,...,n. Enough information will be there to use the respective prices as instruments to determine and regulate domestic and imported quantities since they are treated as distinct goods. Therefore for each i CT(i,t) is either equal to CTd(i,t), and CTm(i,t) for this i is zero, or vice versa. I.e.

$$CTd(i,t) = CT(i,t) \quad \text{for } i=m+1,\dots,n \tag{17}$$
$$CTm(i,t) = CT(i,t) \quad \text{for } i=1,\dots,m \tag{18}$$

3.3
There may be the need to aggregate these identical goods in case available statistics do not report them in isolation. In this case the classification of goods in 2.1. cannot be maintained and must be simplified. We shall then have i=1,...,n goods but cannot determine import demand directly via the demand system. Satisfying total demand for good i (CT(i,t)) domestically or by imports will depend on the users choice of the import regime for the particular commodity (mentioned under a) and b) in 2.1.

Case a) Import demand may be determined according to:

$$CTm(i,t) = CT(i,t) - SUP(i,t) \quad \text{if } CT(i,t) > SUP(i,t)$$
$$= 0 \text{ otherwise,} \tag{19}$$

where SUP(i,t) is domestic supply of good i for period t. Should domestic supply exceed demand and i is a durable good then the production module must provide for running inventories. If i is a perishable commodity the production module must provide for a mechanism of (possibly costly) disposal. In both cases the surplus production may be exported if there is a corresponding demand from the foreign sector. The demanded magnitude may still not be satisfied by actual imports depending on policy restrictions and import prices. Note that CTm(i,t) corresponds to the notional demand for import of good i under the assumption that the price variable in the demand equation represents both the price domestically charged and the import price.

Case b) If imports are general substitutes and not restricted to serve as a buffer they will have to be determined by the consumers. Thus, the situation will be the same as in the case where imported goods are differentiated from local ones. This is the general case which we assume to be the dominating one. We must, therefore, require that information on imported goods be obtained separately and the analysis be followed as in the standard case.

4. Conversion of demand for goods into satisfaction of needs

4.1.
Using conversion coefficients denoted ncoef(i), expressing the amount of the measure of the satisfaction of needs per unit of commodity i, the actual per capita satisfaction level actual(g,t) of group g is given by

$$actual(g,t) = \sum_{i=1}^{n} c(i,g,t) * ncoef(i) \quad \text{all } g,\ t. \tag{20}$$

This magnitude may be compared with a given goal satisfaction level (per capita) denoted goal(g,t). A deficit of the per capita satisfaction for group g is then defined as in the original version of MEPS by

$$Defsat(g,t) = goal(g,t) - actual(g,t). \quad (21)$$

If needed on may also define levels of satisfaction by multiplying actual(g,t), goal(g,t) and Defsat(g,t) with the appropriate group population figure pop(g,t). However, it appears not to make much sense of doing so in the present version because variables expressing needs are no longer converted to goods as in the original version. This fact also changes the possibility of consumption planning. Now, it is not possible to define quantities of goods demanded by defining the goal of needs to be satisfied. One can, however, check the extent to which goals are reached given the income-and-price-driven demand for goods and, thus, also the actual satisfaction. The degree of goal achievement can be expressed by

$$Sat\%(g,t) = 100-[(goal(g,t)-actual(g,t))/goal(g,t)]*100. \quad (22)$$

Sat%(g,t) is 100 if the goal has been reached. In the case of overfulfillment it exceeds 100 and it will be below 100 if the goal has not been reached.

4.2.

Sofar discussion was concerned with the satisfaction of one particular need specified. As commodities are usually capable of satisfying more than one need simultaneously (e.g. supply protein, fat and calories) we generalize the concept in allowing more than one need to be considered. We define the actual per capita satisfaction of need k by

$$Actual(k,g,t) = \sum_{i \in S} c(i,g,t)*ncoef(k,i) \quad (23)$$

for goods i in the index set $S = \{i;\ ncoef(k,i) > 0\}$ and for needs k=1,...,K.

Specifying the conversion coefficient as element of a (Kxn) matrix means that we can group commodities according to which needs they can satisfy. Also note that the ability of a commodity to satisfy more than one need simultaneously is an important property if one attempts to find an optimal mix of commodities satisfying multiple goals. This specification, thus, is intended to provide a link to policy analysis considering the possibility of multiple criteria which may be in conflict with each other. On this issue the reader is referred to the famous "diet problem" of linear programming which has a straightforward extension to multicriteria optimization (cf. Dorfman, Samuelson, Solow (1958), and Rogowski, Sobczyk, Wierzbicki (1988)). For an application to economic policy cf. Böhm/Brandner (1988)).

In analogy to above Goal(k,g,t) may denote a target per capita level of need k and the corresponding deficit can be defined

$$DefSat(k,g,t) = Goal(k,g,t) - Actual(k,g,t) \quad \text{all } k,g,t. \quad (24)$$

Expressed as a percentage ratio we have

$$DefSat\%(k,g,t) = 100-[(Goal(k,g,t)-Actual(k,g,t))/Goal(k,g,t)]*100 \quad (25)$$

for each need k and population group g at period t.

If aggregate average needs have to be considered the following definitions must be observed:
Actual average (per capita) satisfaction of need k in period t is

$$ACTUAL(k,t) = \sum_g (Actual(k,g,t)*pop(g,t))/(Tpop(t)) \quad (26)$$

with

$$Tpop(t) = \sum_g pop(g,t) \quad (27)$$

the total population in period t.

The corresponding percentage deficit of need k given an average (per capita) goal satisfaction GOAL(k,t) is defined analogoulsy as above by

$$DEF\%(k,t)=100-[(GOAL(k,t)-ACTUAL(k,t))/GOAL(k,t)]*100. \quad (28)$$

4.3.
Finally one may want to determine the degree of satisfaction by local goods and by imported ones. As goods i=1,...,m are imported and those i=m+1,...,n are domestically produced simply summing i over the relevant range will yield the desired amounts. We note that by using the conversion coefficients for each separate need we have produced homogeneous quantities able to be summed up. For need k the satisfaction level due to imports is

$$ACTUALM(k,t) = \sum_g \sum_{i \in S, i=1}^{m} (c(i,g,t)*ncoef(k,i))*pop(g,t) \quad (29)$$

and that due to domestic goods

$$ACTUALD(k,t) = \sum_g \sum_{i \in S, i=m+1}^{n} (c(i,g,t)*ncoef(k,i))*pop(g,t). \quad (30)$$

Again, one defines percentages of goal achievement as

$$DEFM\%(k,t)=100-[(GOALM(k,t)-ACTUALM(k,t))/GOALM(k,t)]*100 \quad (31)$$

and

$$DEFD\%(k,t)=100-[(GOALD(k,t)-ACTUALD(k,t))/GOALD(k,t)]*100. \quad (32)$$

These definitions may be used according to the basic objectives pursued by using this modified MEPS system. It is not necessary to compute all of the above magnitudes. An appropriate selection may be sufficient.

5. Excess demand and supply situations

5.1.
Obviously the demand for goods generated in the demand module is not necessarily matched by the corresponding supply of domestically produced and imported goods. The demand magnitudes are determined conditionally on given prices. It will be the responsibility of the production module to provide the relevant price information to the demand side.

Basically, one can think of the following regimes regarding price and quantity determination:

a) Prices are given, e.g. by the world market and the domestic producers act as price takers. If this holds for good i then a quantity-disequilibrium may occur. For the supply module this will imply that cost based pricing might possibly lead to a different price than the given one. As a consequence extra losses or profits will be generated by such differences.

b) Prices are not given externally but are determined in an iterative process involving successive solutions of supply and demand modules. This process requires a price adjustment mechanism depending on the mismatch of quantities. Prices are determined at the level where demanded and supplied quantities are equal (given some tolerance).

c) One could even think of a third way to link supply and demand within the MEPS framework: Assuming the producer of final goods sets the repective prices tentatively in order to find out the quantity of demand generated at these prices. This information is used to apply a different set of prices in case some of the expected results do not obtain. This technique represents a search for the relevant price-supply relationship of the producer where the process can be stopped at any time considered satisfactory by the planner. Disequilibria may or may not result. Therefore, this procedure is a variant of b) where equality of supplied and demanded quantities is not necessarily achieved but some other condition (e.g. profitability of production of the commodity in question) is fulfilled.

A combination of these mechanisms may also be contemplated. For different markets (means final goods produced and demanded) the price setting mechanism could very well be different. What is to be considered is the basic interdependence of demand for the set of final goods to which MEPS is applied. The prices of all relevant commodities will determine the demanded quantities for each good. On the production side this type of interrelatedness is not necessarily so crucial and definitely depends on the production structure.

Both cases a) and c) imply the possibility of rationing of consumers (or producers) under certain foreign trade restrictions. If no such constraints are there the foreign sector (imports and exports) can be regarded to act as a buffer in equilibrating demand and supply. Usually, however, there will be some constraints in effect on the foreign balance, if only on foreign exchange requirements. In the following we shall, therefore, investigate the situations under given prices when rationing can occur and trace out its consequences for the planning of final demand.

5.2
In the standard case domestic (CTd) and import demand (CTm) for good i is determined by incomes and prices. The general balance equation for physical good i taken from the production module is:

$$Df(i) + De(i) + Dr(i) + Dj(i) = SUP(i) + M(i) \quad \text{all } i, \qquad (33)$$

where Df(i) denotes final demand, De(i) exports, Dr(i) demand of the rest of the economy (not covered in the analysis), Dj(i) intermediate demand for input i by the production of good j, covered in the analysis. SUP(i) should denote total domestic supply (which will be disaggregated further in the production part) and M(i) imports. For the following discussion we shall drop time subscripts.

We shall continue to assume good i is a final product if i=1,...,n. Good i will be called an intermediate product if i=n+1,...,q. Then,

$$Df(i) = CTd(i) \quad \text{for } i=m+1,...,n \qquad (34)$$
$$Df(i) = CTm(i) \quad \text{for } i=1,...,m \qquad (35)$$
$$Df(i) = 0 \quad \text{for } i>n \qquad (36)$$

$$SUP(i) = 0 \quad \text{for } i=1,...,m \qquad (37)$$

$$Dj(i) = 0 \quad \text{for } i=1,...,n \qquad (38)$$
$$Dr(i) = 0 \quad \text{for } i=1,...,n. \qquad (39)$$

The last equation holds because the demand module is supposed to cover the whole economy (system). The rest of the economy can, therefore, only demand a commodity as intermediary input into some components not covered in the MEPS analysis.

$$De(i)*M(i) = 0 \qquad (40)$$

if transit trade is excluded. The import quantity M(i) relates to final and intermediate goods. Assuming these categories as non overlapping we have

$$M(i) = Mf(i) + Mj(i) \quad \text{where} \quad Mf(i)*Mj(i) = 0, \qquad (41)$$

and Mf(i) relates to final good imports, Mj(i) to intermediate ones used in production of good j.

For domestically produced demanded goods i=m+1,...,n we have

$$CTd(i) + De(i) = SUP(i) + Mf(i) \quad \text{with } De(i)*Mf(i) = 0 \qquad (42)$$

and free trade when it is permitted to satisfy excess demand for local goods by imported substitutes. If this is not permitted Mf(i) must be set to zero.

If trade restrictions are present then either

a) $CTd(i) > SUP(i) + Mf^*(i)$ (43)

where the starred variable denotes the upper bound of the import restriction for good i. In this case demand cannot be satisfied even by permitting some imported substitutes and consumers are rationed.

Or we have

b) $Ctd(i) \leq SUP(i) + Mf^*(i)$ (44)

and consumers get what they want. If $CTd(i) < SUP(i)$ then $De(i)>0$ is possible. Otherwise inventories or costly disposal must be taken into account.

For explicit import demand (i=1,...,m) demand CTm(i) determines actual imports Mf(i). If the imports are constrained by $Mf^*(i)$ consumers may get rationed in case $CTm(i) > Mf^*(i)$.

For the sake of completeness we may have to consider the case where goods cannot be exclusively categorized as final or intermediate and the equations:

$$Dj(i) = 0 \quad \text{for } i=1,\dots,n$$
$$Dr(i) = 0 \quad \text{for } i=1,\dots,n$$
$$Mf(i)*Mj(i) = 0.$$

not necessarily have to hold. This situation asks for a change in the balance relations with the consequence that it cannot be determined without further rules whether intermediate or final demand has to be rationed if the following situation arises:

$$Df(i) + Dj(i) + Dr(i) > SUP(i) + M(i) \quad \text{all } i. \qquad (45)$$

We shall not pursue this question in the present context.

5.3.

In the case of rationing the quantity demanded under given prices and incomes will not be realized. The constraint will eventually determine the quantity of the good available for consumers. This quantity is reported back to the demand module and should practically affect the variables there, in particular those influencing the degree of satisfaction. Therefore, the constrained quantities result from the excess demand equations:

$$CEd(i) = CTd(i) - SUP(i) - Mf^*(i), \text{ for } i=m+1,\dots,n \qquad (46)$$
$$CEm(i) = CTm(i) - Mf^*(i) \text{ for } i=1,\dots,m. \qquad (47)$$

Then we define:

$$CT^*(i) = CTd(i) - CEd(i) \text{ for } i=m+1,\dots,n \text{ and}$$
$$= CTm(i) - CEm(i) \text{ for } i=1,\dots,m. \qquad (48)$$

Here, CEd(i) and CEm(i) are the excess demands for good i and $CT^*(i)$ are the restricted quantities of good i available for the entire population. How this quantity is distributed among the population groups is in principle quite arbitrary. Usually some groups are more powerful than others in getting what they want, so it will depend on social characteristics and their effects on allocation coefficients (reflecting the groups power) how the groups finally end up to be supplied with goods. Denote the allocation coefficient of group g in period t for commodity i as u(i,g,t). These coefficients may be selected exogenously or could be linked to variables entering the consumption functions. The coefficients obviously must obey

$$0 < u(i,g,t) < 1 \quad \text{and} \quad \Sigma_g u(i,g,t) = 1 \text{ all } i,t.$$

We shall, as an example use a simple proportional distribution where every person has the same weight. That implies

$$u(i,g,t) = pop(g,t)/Tpop(t) \text{ all } i,t, \text{ and } g=1,...,H. \qquad (49)$$

Let excess demand for good i in period t be defined by

$$DIF(i,t) = CT(i,t) - CT^*(i,t) \qquad (50)$$

which is the excess demand for i for the whole population. Group excess demand may then be derived from

$$dif(i,g,t) = u(i,g,t)*DIF(i,t) \quad \text{all } i,t, \text{ and } g=1,...,H. \qquad (51)$$

The effectively rationed per capita demand for good i of people in group g in period t will be calculated from

$$c^*(i,g,t) = c(i,g,t) - [dif(i,g,t)/pop(g,t)]. \qquad (52)$$

All measures of relative satisfaction achievement will now use $c^*(i,g,t)$ instead of c(i,g,t) and variables based upon them.

6. On further relationships between demand and production module and final remarks

6.1.
In the previous section we have analysed the situation between demand and production when prices are given e.g. by the world market. As this need not be the fact for all goods in question the following remarks should indicate how the relationship between the modules could be thought of otherwise.

We start from the assumption that each production component determines costs, investments, government effects and inputs for the production of one product. This product may be used as input to other components or as a final consumer good. We assume several stages of production on which several components may be active. The "total production system" is defined to consist of all stages and components. The resulting magnitudes are e.g. the effects on government accounts, on foreign trade, and will include the quantity produced and the price vector of finally demanded goods based on cost accounting. The quantity produced available for final demand may be considered as given by the demand module at the prices charged in the respective supply components.

The demand module determines quantities of goods demanded by consumers (i.e. groups), at given selling prices (as determined in the production module) and expenditures available for the vector of goods covered in the sectoral subsystem. The expenditures are derived from total incomes, population, social characteristics and possibly also lagged variables relating to the national economy.

At prices formed in the components the quantities demanded influence the scale of production of each component by determining the final product of each component. The intermediary demand for products is eventually also defined by the higher stages of production with the highest stages producing only final goods. Thus, intermediate demand for commodities produced in one component and used as input in another one are recursively defined.

At the demanded levels the production process may lead to either profits or losses for the operation of a single component. As a consequence the producer may be inclined to run the simulation system once again with changes in exogenous variables or parameters in order to improve the accounting statements. This will usually result in changed prices. Having in mind some sort of reaction mechanism corresponding to the "tatonnement process" in general equilibrium theory, it may indeed be possible to reach an "equilibrium" in a particular market. Due to the functional and practical interrelatedness of goods on the demand and production side such "equilibria" will only be partial ones. This makes sense from a practical perspective as different market forms usually prevail in different markets. The attempt to achieve some sort of a "general" equilibrium is bound to fail if only because of the restricted set of commodities usually considered in MEPS applications. On the other hand, the merits of the partial approach may be seen from the spectrum of information generated by the "groping towards equilibrium" approach. Not only will the effects of induced price changes shed light on the movement of quantities of the market itself - and thereby indicating wether there exists a tendency towards equality of supply and demand - but will show reactions throughout the commodities covered in the analysis. This is the consequence of considering substitution effects on the demand and price formation on the production side. Even for rationed goods the change in the degree of satisfaction will be revealed.

As mentioned previously, we may also have the case that the decision about the quantity to produce will result in a deviation from the demanded quantity. This will bring about a partial disequilibrium for certain final goods (or intermediary ones). This imbalance could be thought of stimulating foreign trade to bring about equilibrium in the respective markets (either by selling the surplus output abroad as exports or by buying the deficient quantities from abroad (i.e. imports)), provided there are no trade restraints. In case of restrictions on foreign trade either the consumers or the produceres may get rationed with the effect that desired needs cannot be fulfilled, inventories may have to be kept or some arrangement for disposal must be met. We have discussed this situation extensively in section 5.

6.2.
Finally, a short remark must be made with respect to the national economic level. Demand and production modules provide key relations to national economic aggregates. These links will provide the possibility to undertake tasks in national aggregate planning and some policy analysis. It will crucially depend on the size of the economic sector modelled with MEPS whether one has to provide feedback equations from the sectoral to the national level or whether one can safely do without. This question can not be answered generally for an abstract model but must be tackled within an application. An example may suffice. The price index PCT used in section 3 above is theoretically dependent on the prices of the commodities entering the analysis and will vary with changes in their prices. This effect must be accounted for if the weights of the commodities in the basket used to construct the price index are sizeable, i.e. an influence of their price changes can be traced with reasonable accuracy. It will, therefore, depend on such information as well as the available degree of accuracy whether such feedback relations must be included.

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Part B:

The equation system of the revised demand module

1. General remarks:

The following indices are used:

- i commodity, if i=1,...,m imported commodity only,
  if i=m+1,...,n domestically produced (may be imported under rationing scheme)
- g population group, g=1,...,H
- t time period, t=0,...,T, t=0 base period, t=T final period
- k need to be satisfied, k=1,...K

The numbering of equations does not follow the one in part A. The following equation system represents one possible example among several others which could be deduced fom the text above. One basic alternative specification relating to the link to the macroeconomic sphere is presented explicitly.

2. Equation system:

A) Demand system:

(1) per capita consumer demand for physical amount of good i, consumer group g, in period t:

$$c(i,g,t) = $$

$$= a(i,g) + (1/p(i,g,t))*b(i,g)*[y(g,t) - \sum_{j=1}^{n} (p(j,g,t)*a(j,g))]$$

for i=1,...n; g=1,...H; t=0,...T,
with
$0 \leq a(i,g) \leq c(i,g,t)$ (all t)
$b(i,g) > 0$, $\sum_i b(i,g) = 1$ for all g, i=1,...n.

(2) consumer demand of group g for good i in period t:

$$C(i,g,t) = c(i,g,t)*pop(g,t)$$

for i=1,...n; g=1,...H; t=0,...T.

(3) total consumer demand for physical good i in period t:

$$CT(i,t) = \sum_g C(i,g,t) \quad \text{all i and t.}$$

(4) total physical demand for domestically produced good i in period t:

$$CTd(i,t) = CT(i,t) \quad \text{for } i=m+1,...,n$$

(5) total physical demand for imported good i in period t:

$$CTm(i,t) = CT(i,t) \quad \text{for } i=1,...,m$$

B) Consumer expenditures:

(6) per capita expenditures on commodities $i=1,\dots,n$ of group g in period t:

$$y(g,t) = Y(g,t)/pop(g,t) \quad \text{all } i,g, \text{ and } t.$$

(7) group expenditures on commodities $i=1,\dots,n$ of group g in period t:

$$Y(g,t) = v(g,t)*CNT(g,t), \quad \text{all } g,t$$

(8) total consumer expenditures at current prices of group g in period t:

$$CNT(g,t) = r(g,t)*CNT(t), \quad \text{all } g,t$$

(9) total consumer expenditures at current prices in period t:

$$CNT(t) = CRT(t)*PCT(t)/100 =$$

(10) total consumer expenditures at constant prices in period t:

$$CRT(t) = a0 + a1*(YDT(t)/PCT(t)*100) + a2*Z(t)$$

C) Population equations:

(11) population in group g in period t:

$$pop(g,t) = pop(g,0)*(1+gr(g)) \text{ for } t=1,\dots,T$$

(12) total population in period t:

$$Tpop(t) = \sum_g pop(g,t)$$

D) Satisfaction of needs equations:

(13) actual per capita satisfaction level of need k for group g in period t:

$$Actual(k,g,t) = \sum_{i \in S} c(i,g,t)*ncoef(k,i)$$

for index set $S = \{i;\ ncoef(k,i) > 0\}$ and $k=1,\dots,K$.

IF $DIF(i,t) > 0 : c(i,g,t) = c^*(i,g,t)$ for $i=1,\dots,n$.

(14) deficit in the satisfaction of need k of group g in period t:

$$DefSat(k,g,t) = Goal(k,g,t) - Actual(k,g,t) \quad \text{all } k,g,t.$$

(15) degree of goal satisfaction achievement of need k, group g in period t

DefSat%(k,g,t) =
= 100-[(Goal(k,g,t)-Actual(k,g,t))/Goal(k,g,t)]*100

all k, g, t.

(16) actual average (per capita) satisfaction of need k in period t:

$$ACTUAL(k,t) = \sum_g (Actual(k,g,t)*pop(g,t))/(Tpop(t))$$

(17) degree of average (per capita) goal satisfaction of need k in period t:

DEF%(k,t)=100-[(GOAL(k,t)-ACTUAL(k,t))/GOAL(k,t)]*100.

(18) actual average (per capita) satisfaction level of need k due to imports in period t:

$$ACTUALM(k,t) = \sum_g \sum_{i=1, i\in S}^{m} (c(i,g,t)*ncoef(k,i))*pop(g,t)/Tpop(t)$$

IF DIF(i,t) > 0 : $c(i,g,t) = c^*(i,g,t)$ including the per capita amounts of additional imports required ($\leq Mf^*$)
for i=1,...,m.

(19) actual average (per capita) satisfaction level of need k due to domestic goods in period t:

$$ACTUALD(k,t) = \sum_g \sum_{i=m+1, i\in S}^{n} (c(i,g,t)*ncoef(k,i))*pop(g,t)/Tpop(t)$$

IF DIF(i,t) > 0 : $c(i,g,t) = c^*(i,g,t)$ less the per capita amounts of additional imports required ($\leq Mf^*$)
for i=m+1,...,n.

(20) degree of average (per capita) goal satisfaction of need k due to imports in period t:

DEFM%(k,t)=100-[(GOALM(k,t)-ACTUALM(k,t))/GOALM(k,t)]*100

(21) degree of average (per capita) goal satisfaction of need k due to domestic goods in period t:

DEFD%(k,t)=100-[(GOALD(k,t)-ACTUALD(k,t))/GOALD(k,t)]*100.

E) Rationing equations:

(22) Excess demand for domestic good i in period t:

$$CEd(i,t) = CTd(i,t) - SUP(i,t) - Mf^*(i,t),$$

for $i=m+1,...,n$

(23) Excess demand for imported good i in period t:

$$CEm(i,t) = CTm(i,t) - Mf^{*}(i,t) \quad \text{for } i=1,...,m.$$

(24) Constrained quantity of good i in period t:

$$CT^{*}(i,t) = CTd(i,t) - CEd(i,t) \text{ for } i=m+1,...,n \text{ and}$$
$$= CTm(i,t) - CEm(i,t) \text{ for } i=1,...,m.$$

(25) rationing allocation coefficient for good i, group g in period t

$$u(i,g,t) = pop(g,t)/Tpop(t) \text{ all } i,t,g$$

or a given parameter with constraints:
$0 < u(i,g,t) < 1$ and $\sum_g u(i,g,t) = 1$ all i,t.

(26) excess demand for good i in period t:

$$DIF(i,t) = CT(i,t) - CT^{*}(i,t)$$

(27) group excess demand for good i, group g in period t:

$$dif(i,g,t) = u(i,g,t)*DIF(i,t) \quad \text{all } i,t,g$$

(28) rationed per capita demand for good i ,group g in period t:

$$c^{*}(i,g,t) = c(i,g,t) - [dif(i,g,t)/pop(g,t)].$$

F) Equations which may be used to establish an alternative link to macroeconomic disposable income:

(29) per capita consumption expenditure function for group g:

$$y(g,t) = b0(g) + b1(g)*yn(g,t) + b2(g)*A(g,t)), \quad \text{all } g,t$$

(30) aggregate nominal disposable income

$$\sum_g (yn(g,t)*pop(g,t)) = YDT(t) \qquad \text{all } t$$

Note: equations (29) and (30) can be used instead of equations (6) to (10) if the required information is available.

Part C:

List of Variables and parameters:

Note: Exogenous variables and parameters are printed bold!

A(g,t) **(not specified) variable of group attributes**

a(i,g) **constants in demand system (minimal quantities)**

a0 **constant in consumption function**

a1 **constant in consumption function**

a2 **constant in consumption function**

Actual(k,g,t) actual per capita satisfaction level of need k for group g in period t

ACTUAL(k,t) actual average (per capita) satisfaction of need k in period t

ACTUALD(k,t) actual average (per capita) satisfaction level of need k due to domestic goods in period t

ACTUALM(k,t) actual average (per capita) satisfaction level of need k due to imports in period t

b(i,g) **constants in demand system (marginal budget shares)**

b0(g) **constant in consumption expenditure function for group g**

b1(g) **constant in consumption expenditure function for group g**

b2(g) **constant in consumption expenditure function for group g**

C(i,g,t) consumer demand of group g for good i in period t

c(i,g,t) per capita consumer demand for physical amount of good i, consumer group g, in period t

c^*(i,g,t) rationed per capita demand for good i ,group g in period t

CEd(i,t) excess demands for domestic good i in period t

CEm(i,t) excess demands for imported good i in period t

CNT(g,t) total consumer expenditures at current prices of group g in period t:

CNT(t) total consumer expenditures at current prices in period t

CRT(t) total consumer expenditures at constant prices in period t

CT(i,t) total aggregate consumer demand for physical good i in period t

CT^*(i) constrained quantities of good i in period t

CTd(i,t) total physical demand for domestically produced good i in period t

CTm(i,t) total physical demand for imported good i in period t

DEF%(k,t) degree of average (per capita) goal satisfaction of need k in period t

DEFD%(k,t) degree of average (per capita) goal satisfaction of need k due to domestic goods in period t

DEFM%(k,t) degree of average (per capita) goal satisfaction of need k due to imports in period t

DefSat%(k,g,t) degree of goal satisfaction achievement of need k, group g, in period t

DefSat(k,g,t) deficit in the satisfaction of need k of group g in period t

dif(i,g,t) group excess demand for good i, group g in period t

DIF(i,t) excess demand for good i in period t

Goal(k,g,t) desired per capita satisfaction level of need k for group g in period t

GOAL(k,t) desired average (per capita) satisfaction of need k in period t

GOALD(k,t) desired average (per capita) satisfaction of need k in period t

GOALM(k,t) desired average (per capita) satisfaction of need k in period t

gr(g) constant population growth rate for group g

$Mf^*(i,t)$ upper bound on imports of physical good i in period t

ncoef(k,i) conversion coefficient expressing the amount of the measure of satisfaction of need k per unit of commodity i

p(i,g,t) selling price of good i,in period t, (for group g)

PCT(t) consumer price index (or deflator)

pop(g,t) population of group g in period t

r(g,t) expenditure share of group g in period t, as percentage of total nominal consumer expenditures

SUP(i,t) domestic supply of physical good i in period t

Tpop(t) total population in period t

u(i,g,t) rationing allocation coefficient for good i, group g in period t

v(g,t) expenditure share of all goods i=1,...,n as percentage of total group expenditures for group g, in period t

y(g,t) total expenditure on consumer goods i=1,...,n

Y(g,t)	total group expenditures on commodities i=1,...,n of group g, in period t
YDT(t)	total nominal disposable income
yn(g,t)	per capita nominal incomes of group g in period t
Z(t)	(not specified) exogenous variable

Part D:

Tables of input information and results

1. Input tables

1.1. Population

population group names	people	rate
1 ... H	pop(g,0)	gr(g)

1.2. Demand system parameters

names of goods	group 1 ... H	group 1 ... H	need 1 ... K	prices 1 ... T
1 ... m m+1 ... n	a(i,g)	b(i,g)	ncoef(i,k)	p(i,t)

We assume the same prices to hold for all groups. If price discrimination exists the table must be expanded to permit price variation across groups.

1.3. Satisfaction goals

For each t=1,...,T

group	need 1 ... K
1 ... H	Goal(k,g,t)

1.4. Macroeconomic variables and parameters

variable	period 1 ... T
YDT	
PCT	
Z	

parameters	value
a0	
a1	
a2	

A corresponding table may be set up for the alternative link to the macro-level using equations (29) and (30).

1.5. Consumers expenditure distribution and shares

group	period 1 ... T	period 1 ... T
1 ... H	r(g,t)	v(g,t)

1.6. Rationing

goods	domestic 1 ... T	imported 1 ... T
1 ... m	no entry	$Mf^*(i,t)$
m+1 ... n	SUP(i,t)	$Mf^*(i,t)$

Group distribution of excess demand u(i,g,t) must be given in a separate table if equation (25) is not used.

2. Output tables

2.1 Quantities demanded and excess demand

good	demand period 1 ... T	excess demand period 1 ... T
1 ... n	CT(i,t)	DIF(i,t)

2.2. Satisfaction of needs

For each period t=1,...,T

group	need 1 ... K
1 ... H	DefSat%(k,g,t)
total	DEF%(k,t)
domestic imported	DEFD%(k,t) DEFM%(k,t)